On the Notion of a Resource

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Systems and Problem Solving

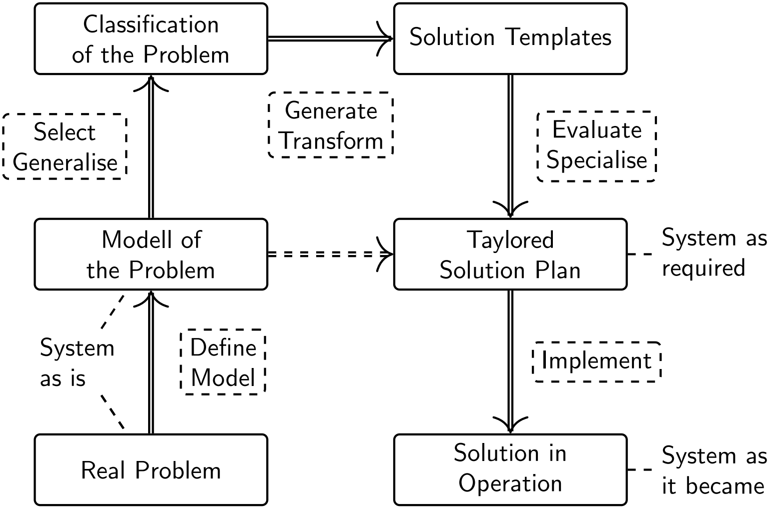
The concept of system is a basic mental tool for delimiting and reducing problems to their essentials.

Such focussing and contextualisation is the prerequisite for further planful proceeding according to Darrell Mann:

- for modelling the problematic situation ("Define"),
- for selection of suitable solution tools ("Select"),
- for generation of solution proposals ("Generate") and
- the assessment and selection of suitable solutions ("Evaluate").

D. Mann stops at this mental stage in his book, which of course must still be followed by the implementation of the solution – "it is not only about interpreting the world differently, it is a matter of changing it" (Marx).

The TRIZ Way of Thinking



Define

This first step in Darrell Mann's approach starts with the delineation of an appropriate systemic context for the study of the problem.

- Delimitation of the system externally against a "living" context as *environment*.
- Delineate the system internally – delineate *components* that either already exist (as *artefacts* or as *services*, i.e. also "belong to the environment") or are available at the time of assembling and operating the system.

This allows concentration on the *internal view* and planning of a *functional solution* to the problem.

TRIZ Concept of the Ideal Machine

In the TRIZ methodology *functional* properties as "usefulness for others" are in the foreground.

The terms *usefulness* and *harmfulness* play an important role in TRIZ alongside the objectives of profitability and efficiency as socio-cultural guiding principles.

With the concepts of *Ideality* and *Ideal Final Result* a mental construct of anticipation of the functional properties of a system stands at the beginning of its genesis.

Koltze/Souchkov, p. 40

The ideal machine is a solution in which the maximum utility is achieved but the machine itself does not exist.

TRIZ Concept of the Ideal Machine

The ideal machine is therefore *pure functionality* without any resource-related underpinning.

Nonetheless, that fictitious idea is central to TRIZ, for it develops a strong orientation towards the intended usefulness and thus has a socio-cultural guiding effect.

Machine here stands very generally for "potentially working solution" and hence applies also to problem solving in socio-technical systems as organisations.

Select, Generate, Evaluate

Here Darrell Mann deviates somewhat from my scheme.

My „Generalise" is rather part of „Define" but not directed towards modelling of the given problem, but at finding a *working conceptual generalisation*.

„Select" appropriate tools requires or is interwoven with finding this working conceptual generalisation.

„Generate" much depends on a good choice of tools and thus of a working conceptual generalisation. Hence the demarcation of the transformation on the higher level of abstraction is slightly different.

This also applies to „Specialise". It is more than mere „Evaluation" since it comprises to taylor a general solution template to the given situation.

In both versions the process ends with a *plan* for the implementation of the solution.

Implement

This phase does not occur in Darrell Mann's work (and in TRIZ in general) in such a clear way as it does, for example, in Design Thinking.

But the DT methodological approach is different: the methodological focus is rather on the multiple rapid (agile) passing through the feedback cycle between real problem and possible solutions instead of precise planning.

Implement

Implement in (or after) TRIZ means:

- Machine must be "built".
- Machine must be "deployed" at the given location and "come to life".
- To do this, the *operating conditions* (import and export) must be provided.
- Which resources are needed (input) and which are made available (output).

What are resources in TRIZ?

On the Notion of Resources in TRIZ

ARIZ-85C:

„Substance Field Resources are substances and fields that are already available or are (easily) obtainable according to the conditions of the task“.

Wessner lists a whole variety of concepts of resources proposed by different TRIZ schools. The spectrum ranges from

- "a means that can be used to solve a problem" (Souchkov)
- to "anything in or around the system that is not being used to its maximum potential" (Mann, Salamatov)
- to the notion of resource as source of a problem itself: "a problem always arises, if a needed resource is not present" (Orlov).

On the Notion of Resources in TRIZ

In (Koltze/Souchkov, p. 51) a resource is understood as "a means, a tool to carry out an action or to make a process take place" and equipment, money funds, raw material, energy or even people (human resources) are mentioned as examples of resources.

Furthermore ressources there are classified according to

- *value* (free, not expensive, expensive),
- *quality* (harmful, neutral, useful),
- *quantity* (unrestricted, sufficient, insufficient) and
- *readiness for use* (ready, to be modified, to be developed).

Specific *qualitative* determinations of such "substances and fields" as resources play almost no role.

Qualitative determinations in the sense of the fulfilment of a *specification* are, however, essential in more complex technical contexts in order to ensure the *operation* of a specific functional property, which is to be provided by a systemic context.

What is the Problem?

The constructed thing (partial system) that has been taken out must be (re)placed in the overall context. But this context can be operated only as a *unified whole* that cannot be disassembled from an operational point of view. The whole can only be operated in an assembled state, and this requirement to be "assembled" does not end at any system boundary either.

It means putting the "dead" partial system (after appropriate preparation) into a "living" (itself being systemically structured) environment and "starting it to operate".

Preparation: In component software, a distinction is made between deploy, install and configure as well as an explicit signal to switch from preparation to operating mode.

What is the Problem?

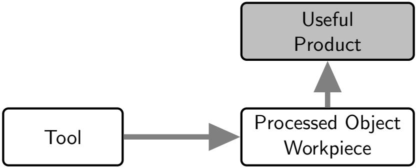
This induces a *further systemic development* of the "living" environment as a systemic complex, i.e. *the whole changes*.

This requirement later to operate the system must already be present in the entire (mental) development process.

How does this throughput of substance, energy and information appear in the TRIZ modelling process?

Operating a Minimal Technical System

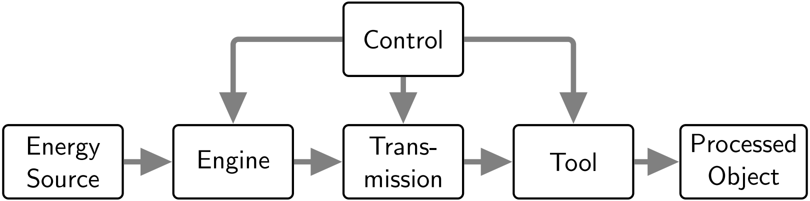
In the TRIZ notion of a *minimal technical system*, a *tool* acts on an *object* (workpiece) to be processed in order to transform it into a *useful product*.



The concept of the *ideal system* considers the tool as a purely functional property, the effect of which to intentionally change the state of the workpiece to a useful product is achieved without any additional efforts and any wear of the tool.

In other words, it is not the tool but the *imaginaton of the tool* that creates the required action in such an *ideal machine*.

Operating a Complete Technical System



In the classical understanding of a *complete technical system*

- the energy throughput is centered on the tool,
- the throughput of substance transports the workpieces
- and the throughput of information is directed to the control of the action.

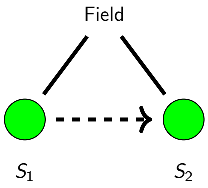
Thus, in any case, the concept of a resource is understood as "means that can be used to solve a problem."

Resources, Tools and State Changes

The understanding of the relationship of action conveyed here is asymmetrical.

An active tool has a state-changing effect on a passive workpiece, while retaining its own functionality and – ideally – without undergoing a state change itself.

In *substance-field models* this understanding is replaced by a more symmetrical model of a field-mediated action between two substances.



Resources, Tools and State Changes

At the same time, in the systemic abstraction, the materiality of the *tool* is pushed back further in favour of the concept of *action* and a component concept is prepared as proposed by C. Szyperski for Component Software.

There, *components* are basically conceptualised as *stateless* with all the resulting consequences. In contrast to this *objects* are conceptualised as state-bearing units of instantiation to maintain a certain standardisation of workpieces required for a repeated application of a function within a production process.

Resources, Tools and State Changes

A similar idea comes through when Souchkov describes the two goals of *Resource Analysis* as essential component of TRIZ:

- Analysis of the resources that are to be *treated or consumed* in the course of a process,
- and analysis of the resources that can be *used* to carry out the process or to solve the problem,

i.e., he distinguishes resources of the first kind, which undergo state-changing transformations as *workpieces* and resources of the second kind, which are used as tools to *mediate* these state changes.

Operation and Maintenance of Technical Systems

Such a notion also corresponds well with the widespread organisation of production processes, where a distinction is made between operating and maintenance mode.

In the operating mode, the focus is on the functional properties of the tool, while in the maintenance mode its material properties are focused.

As an independent technical system in a narrower sense, only the operating mode is modelled as the target of a "problem solution".

The maintenance mode is part of the supersystem, which is concerned with the *reproduction* of the tools as *resources* used in the operating mode.

Operation and Maintenance of Technical Systems

In the (classical) operating mode the focus is on the use of tools and the material throughput of workpieces, which are thereby transformed into useful products, in many cases *technical artefacts*, which are either further processed as semi-finished products in a following technical system or enter into such contexts as tools themselves.

In both cases the useful product is a *resource* for further systemic processes.

But TRIZ is not (primarily) about system analysis but about *problem solving* and the design of viable technical systems in a *systemic development* **process**.

Systemic Development and Problem Solving

Souchkov clarifies the role of *Resource Analysis* in such a process:

> *A technical system has different resources at its disposal for the completion of its function. A function can only be completed using suitable resources. Resources are therefore elementary building blocks of a problem solution. The skilful use of resources distinguishes an efficient from an inefficient system.*

The question of systemic operating conditions is thus reversed – it is not about what conditions are *required* for the operation of a particular system, but what kind of system under *given* operating conditions promises an efficient problem solution.

The focus thus shifts from the operating conditions of an existing system to the question of a systemic development and co-evolution in a given context.

The World of Technical Systems

The operational demand of a technical system is formulated in the form of *specifications* as requirements to the "environment", which must be fulfilled for the *operation* of the system. Thus the "reduction to the essentials" that characterises the systemic approach is only a *conditional* mind game that presupposes a sufficiently powerful *environment* as given, in which the necessary *resources* can be found to fulfil the operating conditions.

Sommerville emphasises the importance of such interface specification for the development of software systems that "need to interoperate with other systems that have already been developed and installed in the environment."

Components as Resources and Component Models

The same perspective is significant when large systems are to be created in a cooperative development process and for this a decomposition into subsystems is required that are to be developed independently of each other.

This development process in turn requires a more extensive socio-technical infrastructure with

1. *independent components* that can be fully configured via their interfaces,
2. *standards for components* that simplify their integration,
3. a *middleware*, which supports the component integration with software
4. and a *development process* that is designed for component-based software engineering.

Components as Resources and Component Models

Components are thus conceptually integrated into an overarching *component model*, which essentially ensures the technical interoperability of different components beyond concrete interface specifications and thus forms a moment of unity in the diversity of the components.

However, this unity extends not only to the model, but also to the operating conditions of the components (as functional property of the middleware) as well as to their socio-technical development conditions (as a partial formalisation of the development process).

This frame constitutes as *component framework* (Szyperski) a socio-technical supersystem as an "environment" of components that were created according to the specifications of that component model.

The World of Component Models

Szyperski, for his part, analyses this diversity of compatibilities and incompatibilities of different component models and identifies different levels of abstraction for the reuse of concepts that go beyond the use of prefabricated components.

In his 20-year-old book he already emphasises

> *the growing importance of component deployment, and the relationship between components and services, the distinction of deployable components (or just components) from deployed components (and, where important, the latter again from installed components). Component instances are always the result of instantiating an installed component – even if installed on the fly. Services are different from components in that they require a service provider.*

Functional and Attributive Properties

Szyperski shows that the component approach is an approach of reuse that is not limited to the (possibly modified) abstract reuse of the technical functionality of a problem solution, but always reuses components together with their operating conditions as *services* and thus not detached from their environment.

For this, Shchedrovitsky's distinction between functional and attributive properties as well as the distinction between the notions of *part* and *element* are essential.

> **Elements** *are what a unity is made up of, so an element is a part inside the whole, which functions inside the unity, without as it were being torn out of it. A simple body, a* **part***, is what we have when everything has been disassembled and is laid out separately. But elements only exist within the structure of* **connections***. So an element implies two principally different types of properties: its properties as material, and its functional property derived from connections.*

Functional and Attributive Properties

In other words, an element is not a part. A part exists when we mechanically divide something up, so that each part exists on its own as a simple body. An element is what exists in connections within the structure of the whole and functions there. [...]

Functional properties *belong to an element to the extent that it belongs to the structure with connections, while other properties belong to the element itself. If I take out this piece of material, it preserves its* **attributive properties**. *They do not depend on whether I take it out of the system or put it into the system. But functional properties depend on whether or not there are connections. They belong to the element, but they are created by a connection; they are brought to the element by connections.*

Filling the Places with Content

The terms *part*, *element*, *connection* describe the *structure* of the place in the system itself, where the connection of the "dead" system with the "living" world must be carried out in order to bring the system itself to life.

In the further system genesis, this conceptual frame has to be filled with suitable resources. How conceptualise this "filling“, the combination of the functional properties at the "connections" with resources to an almost ideal machine?

To describe this composition process ("components are for composition" – Szyperski) Shchedrovitsky distinguishes the concepts *place* and *content*.

Filling the Places with Content

Doing that, we introduce the concepts of place and content. An **element** *is a unity of a place and its content – the unity of a functional place, or a place in the structure, and what fills this place.*

A **place** *is something that possesses functional properties. If we take away the content, take it out of the structure, the place will remain in the structure, held there by* **connections**. *The place bears the totality of functional properties.*

The **content** *by contrast is something that has attributive functions. Attributive functions are those that are retained by the content of a place, when this content is taken out of the given structure. We never know whether these are its properties from another system or not. Now we might take something out as content, but it is in fact tied to another system, which, as it were, extends through this place.*

Filling the Places with Content

The search for resources is constitutive for the process of confinement in the course of the genesis of the system that is to be developed from the pure functionality of the ideal machine. This corresponds to Altshuller's first law of systemic development.

Altshuller's Law of the Completeness of the Parts of a System

The necessary condition for the viability of a technical system is the existence of the main parts of the system **and** their minimal functionality (i.e. viability – HGG).

However, the thing viewed with the magnifying glass as a connection of place and content remains a "dead body", because "a living being has no parts" (Shchedrovitsky).

Connecting Systems. The Operational Dimension

It is of little use to dissect a living frog in order to see how place and content are to be combined, since you cannot study the blood flow in its veins this way.

It is not enough that the plug fits into the socket, the socket must also "have power in it".

Beyond the connection of place and content an operational process dimension is essential for a living system. Shchedrovitsky develops that as a *second concept of a system*. This cannot be explained here.

We are dealing with a typical phenomenon of a modern society, in which the electricity comes from the socket and the milk from the shop. The division of labour in such a modern mode of production leads to the emergent phenomenon of social unity and stratification of the reproduction of infrastructural conditions.

Connecting Systems. The Operational Dimension

The existence, reliability and robustness (resilience) of such an infrastructure has a significant influence on the way people organise their daily lives.

With the insight into ever more complex interrelationships, a concept of resources as "anything in or around the system that is not being used to its maximum potential" (Mann, Salamatov), which focuses on the *exploitation* of resources, becomes increasingly counterproductive and has to be replaced by a concept of resources with socio-culturally institutionalised forms of *resource management* at its center.

The Concept of a Resource and the Mode of Production

Thesis:

The concept of resource exploitation is a characteristic feature of all existing so far forms of a capitalist mode of production.

It manifests a fundamental contradiction of socio-cultural development: without such exploitation we would not have reached the current state of technology, but at the same time we undermine our own conditions of existence.

My historical optimism says that it is nevertheless precisely these means of increasing conceptual penetration of ever increasingly complex interrelationships by which this trend can be stopped and eventually reversed.

The Global Scope of Local Action

The formulated contradiction is of a global, planetary dimension that cannot be solved by the regional disposition of individual power groups over exploitable resources. The division of the world into spheres of influence thus becomes obsolete insofar as in each of these spheres of influence, the transition to a different form of using resources must be organised to avoid a global environmental collapse of the resources used by mankind in the long run.

TRIZ systemic evolution trends of increasing coordination, controllability and dynamisation refer not only to *system-internal development lines*, but also to the coordination *between* systems which are operated by independent third parties.

Qualifying the infrastructural framework, for example, of the power supply system as "supersystem" does not take into account the relations of *mutual interdependency* in such a modern industrial mode of production.